



## IN THE UNITED STATES PATENT &amp; TRADEMARK OFFICE RECEIVED

AUG 22 2000

TECHNOLOGY CENTER 2000

SUBJECT: Serial #: 09/587,465  
File Date: June 05, 2000  
Inventor: Lin, Jing-Cheng  
Examiner: Sarkar, Asok K.  
Art Unit: 2829  
Title: "METHOD OF FORMING MULTILAYER DIFFUSION  
BARRIER FOR COPPER INTERCONNECTS"

## DECLARATION UNDER 37 CFR 1.131

Honorable Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

Sir:

I, Jing-Cheng Lin, hereby state:

1. I am the inventor of Claims 1-26 of the above-identified patent application.
2. Prior to June 01, 2000, I conceived of the idea for A Method of Forming Multilayer Barrier for Copper Interconnects, as described and claimed in my application, and a copy of the invention disclosure describing my invention entered the United States of America before June 01, 2000. The invention disclosure including drawings shows my invention as claimed in Claims 1-26 and particularly described and shown on pages 1-4 of the invention disclosure. The invention disclosure is attached as: Exhibit A. Each of the dates blanked out from Exhibit A is prior to June 01, 2000.

3. George O. Saile & Associates sent to us a Novelty Search Report with a summary letter dated February 02, 2000 (Exhibit B) proving diligence.
4. George O. Saile & Associates sent to us a final copy of the patent application and drawings along with a letter, attached as Exhibit C, dated May 11, 2000, further proving diligence.
5. The invention was constructively reduced to practice by filing of the patent application TSMC99-700, received a filing date of June 05, 2000 and serial number 09/587,465.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Encl. Exhibits A-C

✓ Jing-Cheng Lin      Aug 14 2003  
Jing-Cheng Lin      Date

ENGLISH -- Method of improve barrier performance

Cu is a deep-level dopant in silicon which affect the effective doping concentration and it also lowers the semiconductor minority carrier lifetime and increase junction leakage current. Further scaling of Cu interconnects to 0.13/0.10  $\mu\text{m}$  node is expected to require thinner barrier. Therefore, a better performance diffusion barrier for Cu is considered a necessity for silicon integrated circuit applications.

1.  $\text{SiH}_4/\text{NH}_3$  or  $\text{SiH}_4/\text{H}_2$  soak in situ
2. Sandwich structure ( $\text{W}/\text{W}'\text{SiN}/\text{W}'\text{N}$ ) of barrier..

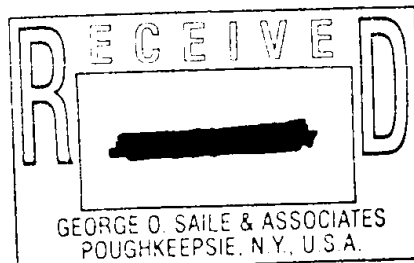
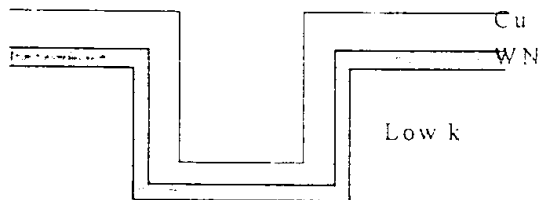
1. WN film after SiH<sub>4</sub>/NH<sub>3</sub> or SiH<sub>4</sub>/H<sub>2</sub> treatment, top surface of WN film would have Si doped in WN film and become WSiN, this will give a better barrier performance.
2. Subsequently deposited W film after SiH<sub>4</sub> soak treatment, this will give a good Cu texture than WSiN

## WN, WsiN, SiH4, Barrier

## W/A

3. Conventionally, the WN film directly used as diffusion barrier in Cu process. Because Cu is a deep-level dopant in silicon which affect the effective doping concentration and it also lowers the semiconductor minority carrier lifetime and increase junction leakage current. Further scaling of Cu interconnects to 0.13/0.10  $\mu\text{m}$  node is expected to require thinner barrier. Therefore, a better performance diffusion barrier for Cu is considered a necessity for silicon integrated circuit applications. (a) WN film after  $\text{SiH}_4/\text{NH}_3$  or  $\text{SiH}_4/\text{H}_2$  treatment, top surface of WN film would have Si doped in WN film and become  $\text{WSiN}$ , this will give a better barrier performance. (b) Subsequently deposited W film after  $\text{SiH}_4$  soak treatment, this will give a good Cu texture than  $\text{WSiN}$ .

Conventional Cu/WN as for future WN is not good enough as a diffusion barrier for Cu

INVENTOR'S SIGNATURE  
DATE:

Comments : (GS) CLAIM A BROAD WS/L/WN BARRIER; CLAIM THE TOP W LAYER AND THE TREATMENT RECIPE IN DEPENDENT CLAIMS.

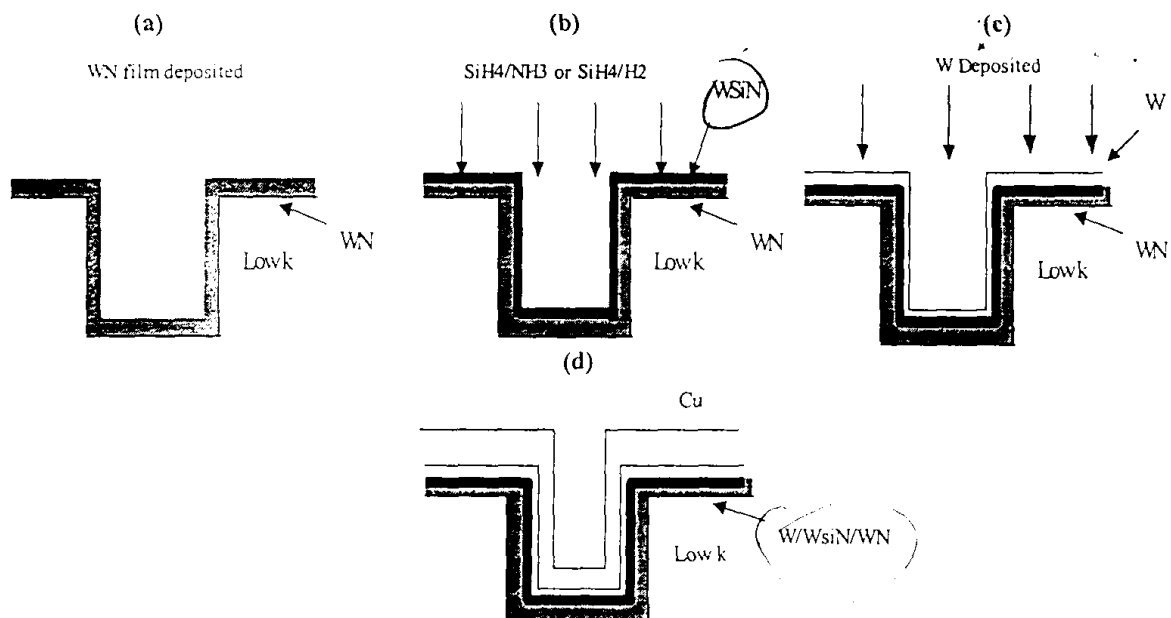
DALE

## DETAILED DESCRIPTION OF INVENTION -- (CONTINUED NEXT PAGE)

SECURITY B

TSMC-REPT

## Improve process



WITNESSES: THE TWO WITNESSES WHOSE SIGNATURES APPEAR BELOW HAVE READ AND UNDERSTAND THIS ENTIRE INVENTION DISCLOSURE.

SIGNATURE OF WITNESS

DATE

Signature of Witness 1

Redacted Date 1

SIGNATURE OF WITNESS

DATE

Signature of Witness 2

Redacted Date 2

DISCLOSURE SUBMITTED BY

INVENTOR'S SIGNATURE

DATE

林俊成

Redacted Date

INVENTOR'S SIGNATURE

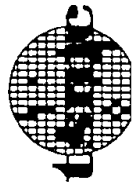
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INVENTOR'S SIGNATURE

DATE

INVENTOR'S SIGNATURE

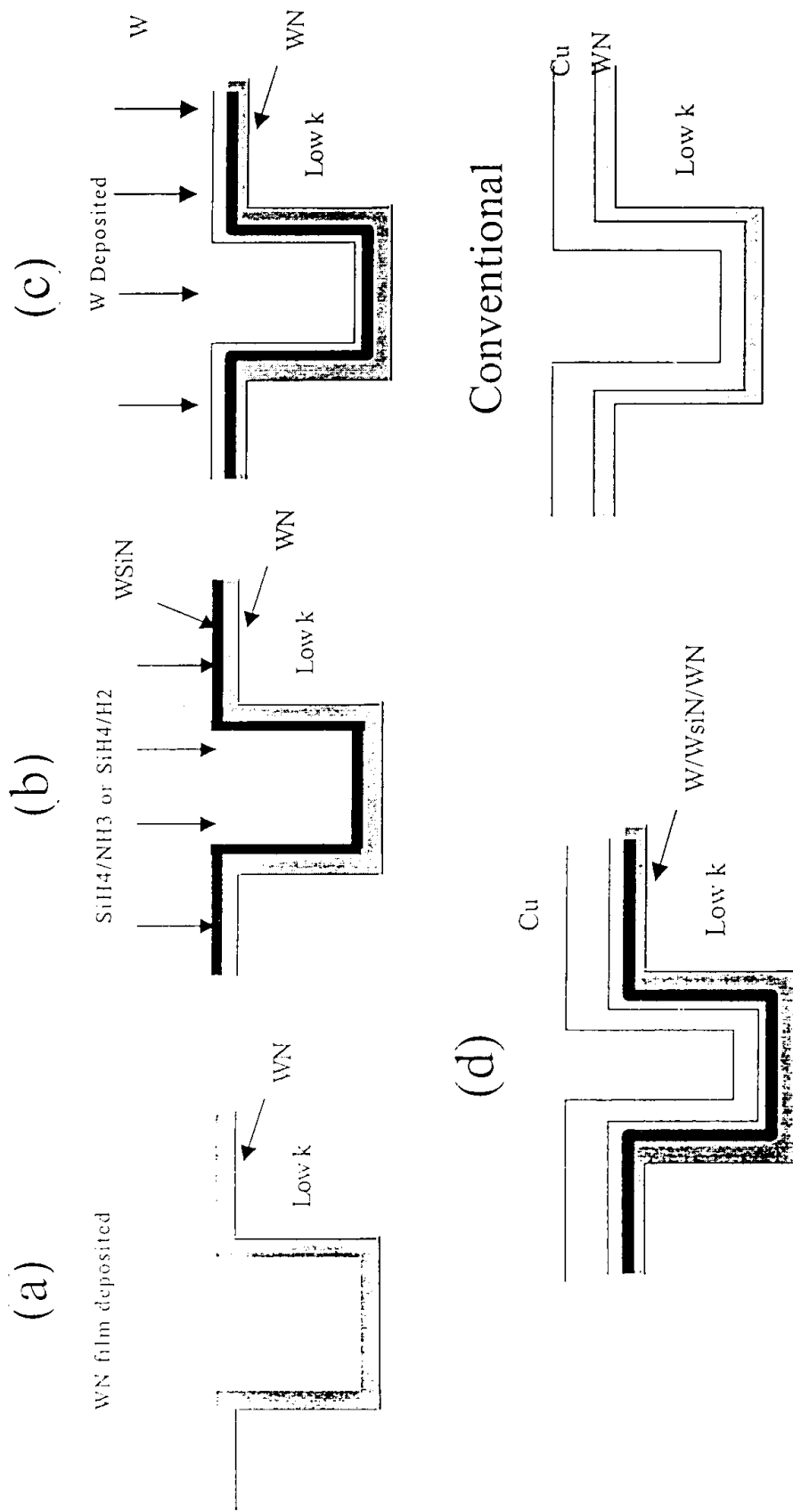
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RD/TFD

1999-750

# New Barrier Scheme



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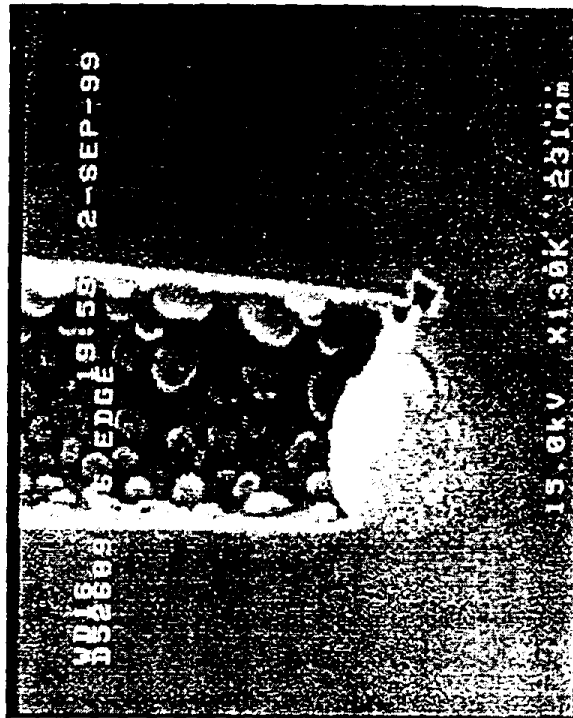
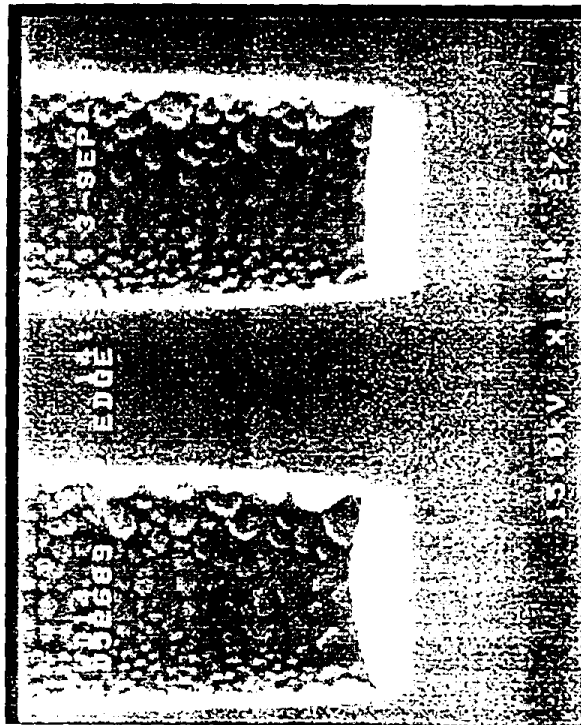


RD/TFD

# Barrier Thermal Stability@400C

W/WSiN/WN

WN



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Exhibit B



February 2, 2000

20 McIntosh Drive  
Poughkeepsie, N.Y. 12603  
Fax 914 4712064

To: D.C. Lin  
Patent Dept.  
TSMC

From: George O. Saile

Subject: Novelty Search at the US Patent Office- TSMC 99- 700 (J. C.  
Lin et al. )

The following is the result of my Prior Art Subject  
search at the US Patent Office.

The invention teaches a method comprising: a W/WSiN/WN  
barrier layer for Cu and a  $\text{SiH}_4$  / $\text{NH}_3$  or  $\text{SiH}_4$  / $\text{H}_2$  insitu soak.

US 6,001,415(Nogami et al.) shows a WSiN and WN barrier  
layers for Cu.

US 5,801,098(Fiordalice et al.), US 5,968,333(Nogami et  
al.), US 5,907,188(Nakajima et al.) and US 5,985,762(Geffken et al.)  
show a various Cu barrier layers comprising W, WSIN and/or WN with  
soak/anneal steps.

In summary, the patents appear close to the invention,  
but do not show the exact details of the invention. I shall begin  
preparation of the invention, but it should be understood that there  
is a question of obviousness and the patent office may object to  
this invention. If you wish you can order the reference patents and  
let the inventors review them, but it is not necessary.

With best regards,

George O. Saile

Exhibit C



GEORGE O. SAILE & ASSOCIATES  
20 MCINTOSH DRIVE  
POUGHKEEPSIE, NY 12603

May 11, 2000

TO: Ashley Hsieh/Joy Chou  
Patent Department  
TSMC

FROM: George O. Saile  
Stephen B. Ackerman  
Fax: 914 4712064

Subject: Patent Application Reference: TS99-700  
Inventors: Jing-Cheng Lin

The subject Patent Application is now ready for the Inventor's signature on the (1) Declaration and Power of Attorney, and (2) Assignment of Invention forms. **Please have the Inventors sign their complete name and in order of first name, then family name.** These forms are enclosed with a copy of the drawings, specification and claims of the Patent Application. The drawings are informal at this time, but will be made formal for filing with the Patent Office and a copy of them will be sent to you.

**SECURITY B**  
**TSMC-RESTRICTED**

Do not make any changes in the Patent Application. But do not make any typographical, etc. errors, and let me know what they are on a separate sheet of paper.

Please fill in the required information on these forms and have the Inventors sign them. Also make copies of these papers for your own files as needed. Please send the original Patent Applications and the signed Forms to me by EXPRESS MAIL DELIVERY. It is important to file patent applications as quickly as possible.

With Best Regards,

Stephen B. Ackerman